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BIOASTRONAUTICS AND EXTRATERRESTRIAL LIFE

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BIOASTRONAUTICS AND EXTRATERRESTRIAL LIFE

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ABSTRACT. Consideration of biological exploration of space as a possible means of determining the origin of life on the earth. Russian and American experiments with probes and satellites are briefly outlined, and attention is given to the possibility of life on Venus, Mars, and Jupiter. The possibilities of extraterrestrial life are closely related to profound structural changes of life material which, on those planets, has adapted to the environmental conditions which are different from those on Earth. A70-46000.

Introduction

One of the most fascinating questions which man faces today, besides the conquest of space, lies in the central problem of bioastronautics, biological exploration of space, as well as in the possible explanation of the origin of life.

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Man has speculated across time about the possible existence of inhabited worlds, but in each case in an uncertain form. In this uncertainty, human imagination has predominated which for a long time has been polarized in so-called science-fiction.

Today with space explorations, the unreal and imaginative situation has taken a more precise and scientific course, since man is now able to create simulating devices which can study the survival of the beings which inhabit the

*Numbers in the margin indicate the pagination in the original foreign text.

terrestrial surface and thus obtain a series of conclusions that later may be confirmed or rejected in future, more complete, explorations.

This interest in problems of bioastronautics arose during 1968, in the fourth Symposium of Astronautics and Space Exploration, which took place between June 24 to June 27 in San Antonio, Texas, in which interesting reports about these matters were presented.

The Field of Exploration of Bioastronautics

The first problem that arises in the field of these explorations is distance. The nearest star that seems to be of any interest from the biological point of view is ten light years away. Remembering that it is impractical to express the distance to celestial bodies by terrestrial standards — such as the kilometer or mile — due to the difficulty in handling such large terms, and to cope with this difficulty, astronomers have come up with the light year as a measure, which represents the distance through which light travels in a vacuum in a year. Practically, a light year is equivalent to 10 billion kilometers, thus positioning the star just mentioned at a distance of 100 billion kilometers from Earth, remembering, as a comparison, that the mean distance between two galaxies is a million light years.

Coming back to the subject of the nearest star of biological interest (ten light years), it would require a minimum velocity of 30 km/sec (hard to obtain permanently, even though Apollo VIII and X obtained the 38 km/sec velocity required to escape the Earth's gravitational field and head towards the moon). Even when this was acquired, the trip would take at least 100,000 years, not considering the return trip. This not only rules out the possibility of human beings getting there, but also the possibility of maintaining the innumerable and delicate instruments which the spacecraft would have to carry.

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It is possible that the technical problem of propulsion could be solved, since at the present time a series of studies and experiments are being carried out by the Russians as well as the Americans to utilize atomic energy to reach

velocities on the order of 60,000 km/sec. However, it would still take 200 years for a round trip, which is outside the range of today's technology.

Due to all of this, we must exclude for a long time the possibility of traveling beyond our solar system, since we must remember that Venus is at a minimum distance of 40 million kilometers, Mars — 57, Jupiter — 587, and the most remote one from Earth, Pluto, lies at a distance of 4,350 million kilometers away.

In the present space exploration program, Mercury has been totally excluded due to its proximity to the Sun. Pluto and Uranus had also been excluded due to the great distance between them and Earth, but according to the latest plans it has been decided to send a special vehicle to Jupiter, Saturn, and Pluto.

Experiments Performed up to the Present

The Russians have sent space vehicles which were called Venus or Venera. The last two have landed softly by means of a special system of parachutes on the 16 and 17 of May of the present year.

These vehicles that the Russians have launched weighed 1,130 kilos, and according to information it seems that they have deposited 405 kilos of instrumentation.

The last landing of a Russian space vehicle took place on October 18, 1967 with "Venus 4". These spacecraft took about four months to reach their objective.

The Americans, on their part, have sent the "Mariner" series which up to now have passed by but have sent back interesting data that coincide with the data of the Russian Venus spacecraft.

At the present moment, it is foreseen that a "Mariner" weighing 405 kilos will study the surface and atmosphere of Mars with the objective of establishing future bases for experiments in the search for extraterrestrial life.

These American vehicles contain an infrared spectrometer to measure the spectral energy coming from Mars' lower atmosphere; an infrared radiometer to measure the thermal energy coming from the Martian surface; an ultraviolet radiation spectrometer to determine the components of the atmosphere.

They also carry photographic television equipment as well as a device to measure the atmospheric pressure, density and variations of latitude and altitude.

Hypothesis on the Possible Existence of Life on Venus

Up to the present, the only existing data on the constituents of the atmosphere of Venus are those obtained by the Russian Venus and the American "Mariner". (We still do not have the data obtained by the last two Russian vehicles which arrived on Venus on the date already mentioned in May.)

The atmosphere of Venus is made up of CO₂ gas which may reach up to 90%. /665
Nitrogen is completely absent, and hydrogen exists in a small content (up to 1.5%). It contains some water vapor, and oxygen seems to occupy from 7 to 14% of the atmosphere.

The Russian experts affirm that the atmospheric density on Venus is 15 times greater than that of the Earth. All these data have been confirmed by the "Mariner 2" and "Mariner 4" data sent to Earth.

The problem that has caused some controversy is the atmospheric pressure and temperature, even though they were totally confirmed by Venus 5 and 6.

"Venus 4" reported a surface temperature of 270°C and an atmospheric pressure of 20 atmospheres, while "Mariner 4" reported the same data for an

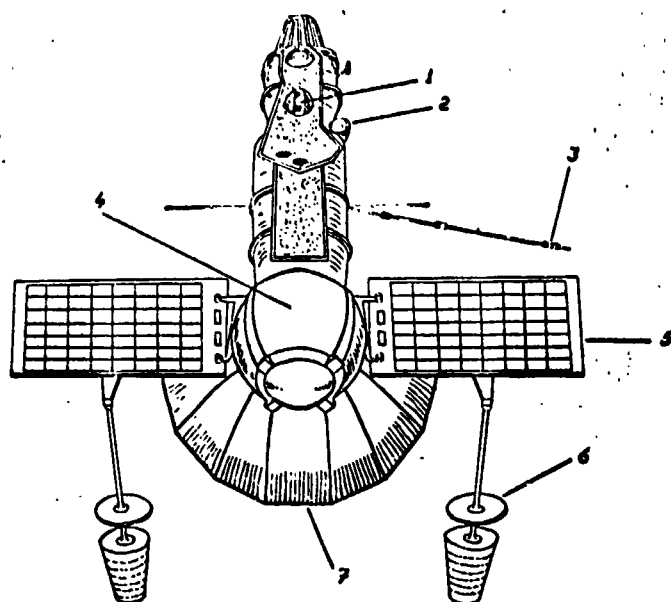


Figure 1. Space vehicle "Venus 4". It carries the capsule (4) which is equipped with instruments and a parachute. 1 - optic system for astro-navigation; 2 - solar sensing capsule; 3 - magnetometer; 4 - launching capsule; 5 - solar panels; 6 - low frequency antenna; 7 - high frequency antenna.

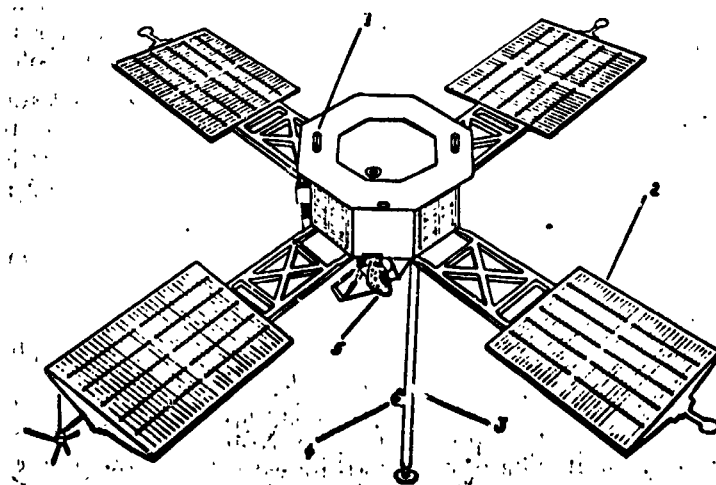


Figure 2. Space vehicle Mariner IV. 1 - solar sensing capsule; 2 - solar panels; 3 - low frequency antenna; 4 - magnetometer; 5 - high frequency antenna.

altitude of 25 kilometers.

The American astronomer Von R. Eshleman, who consulted the Russians in Kiev on this discrepancy, decided that the Russian vehicle had stopped emitting data at an altitude of 25 kilometers, and therefore, the atmospheric pressure of Venus would be around 70 to 150 atmospheres, with a temperature of the order of 327°C to 527°C, which was the last temperature recorded by the last two /666 Venus space probes which reached the planet.

Evidently, the existence of such temperatures rules out the existence of life as we know it on Earth.

On the other hand, the Russians have tried to explain the physical composition of the planet Venus. Thus, the geochemist Aleksander P. Vinogradov assumes that Venus is a hot rocky desert, impregnated with oxides of iron, and that its intense evaporation is caused by its proximity to the Sun. Venus' atmosphere, like our own, has the peculiarity of absorbing infrared rays.

Obukhov states that the climate of Venus is typically cloudy, but lacks precipitation.

Another notable characteristic which was detected by the space probes is the so-called "vertical adiabatic gradient" which was 10.4°C/km for the atmosphere of Venus, whereas it is 10°C/km on Earth, which gives us similar conditions. This is what is presently known about the composition of the atmosphere of Venus. But the basic question is to find out whether there is any possibility of life. We have seen that carbon (CO₂) dioxide exists just as does oxygen. The temperature and the atmospheric pressure are very high.

The first thing we have tried to investigate is the possible origin of carbon dioxide. There are two possibilities. One is of geochemical origin: the decomposition of the surface carbonates on Venus by heat, which the Russians assume. On the other hand, we have the theory defended by the Nobel prize winner Libby and held by several experts who affirm that it may be due

to the existence of vigorous vegetation which could be compared to the carbon dioxide which existed in great quantities during the development of an exuberant flora, still primitive.

The latter experts (attempting to substantiate this hypothesis) try to correlate similarities between the Earth and Venus, since they have comparable dimensions (Earth's diameter is about 12,756 kilometers, while Venus' diameter is 11,996 kilometers which is 0.98 that of the Earth). They have similar mean density (the Earth's is 5.52, while Venus' is 4.44). This might indicate that they possibly have the same chemical composition and even a similar history of eruptions

The problem of temperature still remains. It is true that the vehicles have not detected temperatures at different latitudes. Assuming that the physical state of Venus is similar to that of the Earth, this is the reason for the theory that the higher temperatures predominate around the equatorial band where the solar rays hit directly. On the poles, it is speculated that there are ice caps with heights of up to ten kilometers which extend to a latitude of 45°, which means that this ice could have been formed by volcanic water vapor.

Between these two bands zones could exist with a moderate temperature which would facilitate the presence of small amounts of water and, consequently, of living organisms.

If we are to assume the possible existence of a temperature which could support life as we know it on Earth, we must study the possible compatibility between forms of life on the Earth and such an extreme atmosphere like that of Venus in terms of its carbon dioxide content.

A group of experts headed by Libby started during 1968 a series of experiments simulating the atmosphere of Venus. The first tests have taken place /667 under a 100% carbon dioxide atmosphere which is more much extreme than the

real situation; the temperature used was equivalent to an average temperature on Earth. The pressure used was sea level pressure.

Only a certain member of algae, especially the species *Chlorella Vulgaris* were able to develop under the extreme atmosphere, out of all the plants that were used in the experiment.

Presently, further experiments are being made with the algae that survived the above conditions, but under the high pressures similar to those observed on Venus.

Brock, of the University of Indiana, is running experiments, independently from Libby's, on the possible existence of life at high temperatures.

It is well known that living creatures may exist in hot waters, particularly in volcanic eruptions or geysers. Very unusual flora and fauna have been found in the geysers, capable of resisting temperatures up to 75°C. Protozoas, mushrooms, and several types of blue algae have also been found.

A temperature of 95°C (boiling point of most geysers) allows bacteria to exist; this has been the subject of experiments by Brock, with satisfactory results.

One can conclude that since even terrestrial forms of life can adapt to extreme conditions which may not be exactly like those of Venus — some kind of life may exist on the planet even if it is more primitive than that on the Earth. The forms of life which best adapt to such extreme conditions as intense cold (as is the case with the permanently frozen lakes of Siberia), temperatures which reach boiling point (the already mentioned geysers), and the microorganisms which reign in the depths of the oceans under pressures of 700 to 1,000 atmospheres (much higher than those on Venus) develop perfectly even when their organization is very primitive with hardly any differentiated organs. They represent traces of the first beings which inhabited the Earth under conditions equivalent to those on Venus.

Theory on the Possible Existence of Life on Mars

On June 14, 1965, "Mariner IV" transmitted to Earth a series of interesting data while it passed Mars at a distance of 5,600 miles. These data included a set of pictures taken in groups of 21 at 48 second intervals, thus covering different parts of Mars.

From the data obtained, it has been estimated that the mean temperature is about 50°C less than that on Earth, with great daily variations of the order of 100°C.

It was observed that around the equator, the temperature goes from 30°C to -70°C during the Martian summer.

The atmosphere contains mainly carbon dioxide at a proportion of almost 100%, with a small amount of water vapor.

Up to the present, oxygen has not been detected nor has nitrogen. That is the reason behind the belief that Mars receives a very intense ultraviolet radiation if it has no other type of protection. A magnetic field is also absent, and it is thus more exposed to intense solar wind bombardment.

Atmospheric pressure seems to be so small that it is more than one hundred times smaller than pressure at sea level on the Earth.

As one can observe, conditions on the planet Mars are not adequate for life to exist there. The only feature it has in common with respect to the atmosphere of Venus is the great amount of carbon dioxide. The other conditions are completely different. But in spite of this, there are many reasons to believe that life may exist there, and that this life may be compatible with that of beings which live on the Earth.

It is also known that the topography shown by the photos sent by "Mariner IV", indicate a very rough surface, which may create, from the polar zones to the Equator, a great diversity of localized micro-environments with unusual illumination factors, temperature factors, etc., all of which may facilitate the development of several types of beings.

Although its diameter is less than half the diameter of Earth and its mass is one-tenth of the Earth's mass, its inclination with respect to its orbit and period of rotation make its diurnal rhythm, supplemented by seasonal variations, very similar to the ones on Earth.

In order to find more about this atmosphere, the U.S.A. launched "Mariner VI" last month, on the 25th of February. At the end of 165 days, it should enter Mars' orbit and then start to send information back to Earth to solve all the unknown problems and to find out if there is, or if there ever was, life on that planet.

Many investigators are experimenting in the laboratory by "reproducing the Martian atmosphere" (Young, et al; Packer, et al). They have found that certain micro-organisms may survive several months under thermal oscillations which varied from -60°C to $+20^{\circ}\text{C}$ and under very intense ultraviolet radiation.

Another proven fact is that certain organisms, which were subjected to thermal treatment for four hours at 25°C and the rest of the day at -70°C , with this done under several repeated cycles, were able to survive. It was also found that they could adapt to this environment, and that they could reproduce by division. Other thermal experiments were also performed, always simulating the possible conditions of thermal fluctuations on Mars, and they also adapted to these extreme temperatures. It may thus be concluded that at least elementary organisms exist on Mars.

Professor Siegel, who is associated with Union Carbide Research Institute, has published an unusual work under the title, "An Experimental

Approach to Extraterrestrial Biology", in which he used highly developed plant life.

The importance of Phytohormones is well known in the development in plant life. They regulate and condition the processes of growth and development of plants, which are sometimes conditioned by ecological factors, especially temperature, light, oxygen, water, etc. Siegel directed his studies toward the possible results which the existence or non-existence of oxygen could have in the Martian atmosphere in the liberation of phytohormones, which are responsible for growth.

In these experiments performed in the "Martian simulators", results were obtained which indicated that terrestrial plants which can survive in atmospheres with a low oxygen content could exist on Mars.

Experiments were performed with kidney beans and peas, which developed perfectly in an atmosphere which contained only 5% oxygen. It was established that the metabolic processes of these plants underwent great transformations, and the total content of lipids, especially fatty lipids, was half that which would develop under a normal atmosphere. The carbonic hydrates (starches, cellulose, and sugars) were 200-300% higher than normal. This means that the decrease of oxygen with a high proportion of carbon dioxide increased the photosynthesis process, especially with respect to the cellulose. This substantiates the hypothesis that, during the Carboniferous period, the terrestrial atmosphere had a composition which was similar to the Martian. This established the tremendous development of forests of ferns which, with the enormous amounts of cellulose, represented the essential material for the formation of mineral coal deposits which exist on the Earth. It has also been found that the lignin content, (the product which forms part of the cell walls of plants and whose chemical composition is presently being clarified) was approximately 40% less than that of normal plants.

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These experiments also indicated that there is a slight dependence between oxygen content and temperature. The experiments showed that pickle plants subjected to a Martian atmosphere containing 2% oxygen developed perfectly with a temperature of -10°C , whereas they rapidly died if the temperature was 0°C with an oxygen content of 20%. It was found in most of the plants studied that a decrease in the oxygen content caused an increase in the resistance to cold, which apparently would facilitate life on Mars.

It has been speculated that there are nitric oxides in the Martian atmosphere, and this could prevent the development of any kind of life. That different authors, including Siegel, have shown that many plants like rye can germinate in an atmosphere devoid of oxygen, which is replaced by an atmosphere containing N_2O .

Similar results have been obtained with different seeds of rice, tomatoes, and beans, which were subjected to an atmosphere of nitrogen with nitric oxides.

All of these experiments indicate that, in theory, a certain type of life may exist, in which there is a small amount of oxygen, low pressure, great fluctuations during the day in temperature, ionizing radiation, etc.

The problem of water remains to be solved. Siegel indicates that Mars is a planet which is old geologically and that its surface, which is red, indicates that it is a typically laterite surface, rich in iron, similar to the tropical areas on the Earth. From all the data obtained up to the present, it has been noted that the amount of water is low, which would limit the possibility of any type of life which depends on water, such as we are familiar with on Earth. The absence of water implicitly indicates the lack of any form of life.

We have omitted the hypothesis that frozen land could exist on Mars, as well as a frozen layer located a certain depth below the surface. The existence of water is always possible, at least that which is called juvenile

water having purely volcanic origin. It is apparent that all the planets have a more or less similar origin, although they may differ in their present developmental stage. We may assume that there are oases extending a varying distance over the surface of Mars. In order to prove the existence of plants which could resist the complete absence of water, several unusual experiments have been carried out on a total of 100 species of plants that grow in desert regions. These studies have indicated that the Peru cactus and an African Aloe, which belong to the succulent class, could adapt to extreme conditions. When placed in an environment with no water for three months, several coniferous species survived, including the small Swiss pine, the Japanese dwarf yew tree, the Atlas blue cedar and the black pine. It was shown in all of these cases that, in addition to the resistance to lack of water, there is a close relationship between oxygen deficiency and resistance to low temperatures.

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Experiments have also been carried out with animals as well as with plants to test their adaptability to conditions on Mars.

As was assumed, they had more difficulty in adapting, although there were some surprising cases. The red land turtle managed to survive under an atmospheric pressure equal to that at an altitude of 16 km for more than three months. There was an unusual anomaly in that all warm-blooded animals, especially man, reacted to the lack of oxygen with an increase in the number of red corpuscles. This produced a physiological hipereritrosis. This did not happen to the red land turtle, although there was a point when the reduction was such that the turtle could not maintain an adequate circulation, even when normal cardiac rhythm continued.

In the majority of cases, an amount of 1.5% oxygen was more than sufficient to maintain the activity of many adult insects.

It has been shown that, when atmospheric pressure decreases below that of 6 km in altitude, wasps and bees are unable to jump or fly in the air. This fact has led Siegel to state that, if there are any flying forms of life

in the atmosphere of Mars, they must have a very different constitution from those forms of life which fly in the terrestrial atmosphere.

Another surprising result has been the fact that lichens have been able to resist ultraviolet radiation 4,000 times greater than that which they receive on the Earth. It has also been found that lichens and moss can resist gamma radiation on the order of 500,000 radons, which is 1,000 times greater than the lethal dose for man.

All of the results achieved in the laboratory have shown us the great plasticity which certain forms of life, animal or vegetable, display when subjected to conditions similar to those which are known to prevail on the surface of Mars. It is therefore logical to assume that a particular kind of life has been able to adapt to the Martian conditions. Just like on the Earth, there must have been an evolutionary history of the planet with biological solutions, which may have been superior to those on the Earth, and thus that which we understand by life on our planet could have been established.

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Hypothesis Regarding Possible Existence of Life on Jupiter

Many researchers feel that Mars has reached the end of its development, whereas Jupiter is at the beginning of its development. It must be remembered that this planet is extremely cold, although it is possible that in certain extremely dense atmospheric layers there are temperatures ranging from 0° to 80°C, which favor the formation of immense clouds of organic material and probably primitive organisms.

Up to the present time, the only models on the atmosphere of Jupiter are based exclusively on studies regarding the gravity, composition of the planet's satellites, as well as spectroscopic analogies.

It is believed that the highest part of the atmosphere of Jupiter is composed of a layer having a base of ammonia vapor, another layer of

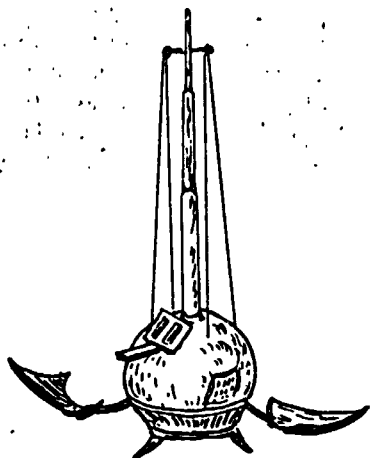


Figure 3. General sketch of planned vehicle for the program of Philco Corporation Aeronautic Division. This vehicle will land on Mars and will carry out a series of earth-directed tests to determine the possible existence of microorganisms.

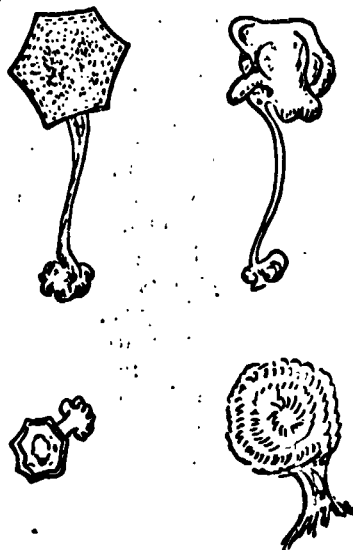


Figure 4. *Kakabekia Umbellata*. Organic fossil which is presently in Scotia and which dates back two thousand million years.

microscopic drops of water, and, finally, a layer of solid or liquid hydrogen. All of these layers could contain substantial amounts of methane, hydrogen, helium, ammonia, and neon. The planet has a strong magnetic field and a diurnal cycle of 10 hours, which leads to a rapid change between heat and cold.

Doctor Pannamperuna of NASA has carried out unusual experiments using simulators of the atmosphere on Jupiter, and the results have been very promising.

Jupiter may very well contain the origin of life, which we shall explain by means of two recent discoveries. One deals with ancestry, indicating the the primitive constitution of the Earth, (similar to the actual atmosphere of Jupiter) and the other deals with synthesis performed in a laboratory.

Professor Siegel was carrying out investigations about living organisms which develop under very unusual conditions, when he found in the foundations of the Harlech Castle in Gales a microscopic form of life having a diameter of five microns. It had adapted to an atmosphere of methane and ammonia, sometimes mixed with oxygen and sometimes not. He was able to cultivate this in the laboratory for more than six months without being able to relate it to any existing species of life.

In 1965, Dr. Barghoorn of Harvard University and a geologist at the University of Wisconsin, Stanley Tyler, published their discovery of very old Canadian rocks dating back some two thousand million years, which is the oldest fossil which has been found up to the present and which was named Kakabekia Umbellata. It was shaped like a micro-umbela, exactly like the one Siegel found in the foundations of Harlech Castle.

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This indicates that this form of life, like all other forms of life which have continued through time without being extinguished or modified in any way, has stayed in one place and has retained the characteristics of the primitive environment.

Siegel was later able to show how microorganisms can exist in atmospheres having a base of ammonia-methane.

It has been established that the primitive atmosphere on the Earth two thousand million years ago was made up primarily of ammonia, methane, and water vapor, with no oxygen. The Kakabekia fossil indicates that a series of microorganisms developed which did not require oxygen for their vital activities, which is shown by the Kakabekia which lives at the present time. The sediments in which the Kakabekia fossil has been found illustrate the transition from a reducing terrestrial atmosphere to an oxidizing atmosphere, which exists today.

This illustrates for us the tremendous interest in bioastronautics. The planets are laboratories showing us how the elemental forms of life have

started at the same point of origin and have evolved in a very diverse form in the course of four thousand million years.

This origin of living matter has been reproduced recently in laboratory experiments. This synthesis of organic material is the result of a work published by the Russian, Oparin, in 1924 in the book, "Origin of Life". He defends the thesis that life was initiated in a microscopic, unicellular form, with an elemental archiplasm and dispersed molecules of nucleic acids.

Recently, Professor Sidney Fox, Director of the Institute of Molecular Evolution of the University of Miami, has published the results of experiments performed in his department.

The experiments employed an atmosphere based on carbon dioxide, methane, ammonia, water and hydrogen vapor, which is absolutely similar to the primitive atmospheres of the planets. This experimental atmosphere was subjected to intense ultraviolet radiation and electric discharges, with an initial mixture of dry amino acids.

We may recall that amino acids are the basic substance of proteins. These dry amino acids were subjected to temperatures on the order of 100°C, producing a chain reaction, retaining the bonds between them by bonds, which is similar to that of actual proteins. The final result was what Sidney Fox has called proteinoids. The proteinoids have a specific sequence, indicating that the initial amino acids had a certain oriented organization. The proteinoids are organized in structures or microspheres, which can produce buds, which in their turn produce new microspheres. In each phase of this evolutionary cycle self-organizing mechanisms appear, which are responsible for the constitution of a living system.

We first have proteinoids and amino acids, followed by a certain orientation toward the environmental conditions (organic sensitivity), and, finally, a continuation (maintenance of the living form). These three characteristics are indicative of a living being. There is an organization

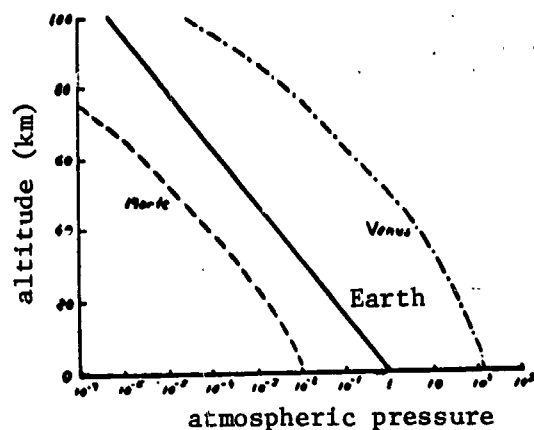


Figure 5. Graph comparing the atmospheric pressures on Mars, Earth and Venus.

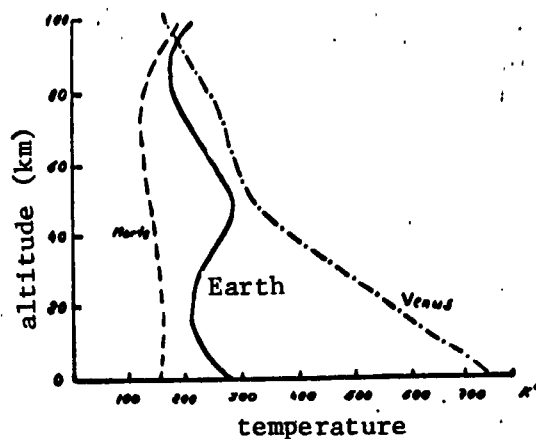


Figure 6. Graph comparing the atmospheric temperature on Mars, Earth and Venus.

which is transmitted, possibly by means of the self-reproductive mechanism, by the same method that viruses use.

Characteristics of living beings are controlled by the nucleic acids. Similar experiments have been made which produced these bodies, although a stable self-organization was not achieved.

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As Harold Klein has established, all of this poses delicate problems for the so-called biological probes which have been planned. They must perform delicate tests to distinguish what is in reality a living being, i.e., a material being capable of interchanging material with the environment, transforming energy, reacting with the stimuli of the environment in order to be perpetuated. This type of living being must be distinguished from that which cannot perform these vital functions.

A launching program of biosatellites is planned for 1970 to clarify all of these questions.

Final Considerations

(a) The pressure curves corresponding to Mars, the Earth, and Venus are practically parallel. The Earth and Venus have almost the same gravity, although they differ in temperature. They have pressure lines which are almost parallel, owing to the fact that the average mass of molecules in the atmosphere of Venus is much greater.

On the other hand, Mars has a lower gravitational value, a higher molecular mass and a lower temperature, which makes the pressure curve almost parallel.

(b) The temperature on the surface of Mars is approximately two-thirds of that on the Earth, and a third of that on Venus measured in Kelvin degrees.

(c) The possibilities of life are closely related with the profound structural changes in living material which could develop on these planets.

(d) The exploratory, biological experiments are aimed at the construction of a space vehicle which could set in operation a centrifugal mechanism to determine the minimal gravity required by plants and animals, as well as the relative biological value which is necessary to adjust to the artificial gravity.

(e) It is necessary to study the biological rhythm of organisms which are not under the direct influence of the Earth and are subjected to the corresponding influence of other planets. This is the purpose of the Bio-pioneer project planned for 1972-73.

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